Synopsis

Ph.D in Resource Management

Exploration of Domestic Water Management Practices and Paradigm Shift using IoT Enabled AI System for Devising Water Conservation in Ingenious Homes

By

J.Sofia Jannet

17PHRMP003

Supervisor

Dr.M.R.Thilakam

Professor and Head

Department of Resource Management

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Introduction

Water quality and purity are the two most important factors to consider because they have the potential to put our ecosystem at risk by affecting its overall health. We were taken aback by the fact that the purity of the water continues to deteriorate during transportation and storage at home.

The quality of available water and excessive consumption were considered to be fields that belonged to a specific niche. Both of these legends of our current state must be addressed together in order to be fully understood. To combat water shortages, some of the old-fashioned methods of dealing with them are regaining popularity. Modern technology has stepped into upgrade the methods and make them applicable to current lifestyles. Despite the fact that the government has implemented new policies and programmes to address the city's water crisis, they are still in a position to resolve the problem throughout the entire city. As a result, it is imperative to educate and encourage homemakers to espouse water conservation practices while also ensuring the quality of the water, which is a viable option for reducing residential water consumption.

Statement of the Problem

Based on these considerations, the following research questions were developed for the study.

1. Whether the Homemakers of Coimbatore city are committed to the general principles and practices of domestic water management?

2. How satisfied were the households with the existing water supply, storage, as well as the quality and quantity of the water that was provided?

3. Is it possible that the programme designed to disseminate information will have an effect on the homemakers of Coimbatore city in terms of their knowledge, attitudes, levels of behavioural change, and practices in relation to domestic water management?

The major goal of the research was to investigate the present practices of domestic water use practices among the homemakers of the selected city Coimbatore and to propose a high-tech tool for the administration of residential water management.

In order to carry out the research, the following goals were established.

- Recognize the socio-demographic profile of respondents as well as their degree of awareness, knowledge, attitude, and lifestyle regarding domestic water consumption.

- Identify the sources of water, supply design, storage practices and water consumption pattern in selected homemakers of Coimbatore city.

- Evaluate the quality of water – physical, chemical and biological qualities that has been stored for drinking purpose among the selected water samples.
- Investigate (micro-component) individual water utilisation for different domestic activities in chosen houses.
- Design a prototype model of IoT based effective water usage monitoring and control system using Transmission Control Protocol/ Internet Protocol (TCP/IP) that could be used for water conservation.
- Plan, carry out, and assess the effect of an intervention programme on chosen homemakers' knowledge, attitudes, and behaviours on domestic water usage.

Review of Literature

Water Scarcity

Dehghani *et al*., (2021), water scarcity is described as a condition where water demand exceeds over available water supply. A country or a region faces "water scarcity" when the availability of natural hygienic water falls below 1000 m^3 per person per year.

Water quality

Since water has the primary property as a ***universal solvent***, it also holds impurities that are dissolved in the water. There are two ways by which the impurities get into contact with water, come as:

- Natural
- Human activities/ handling

Natural - like atmospheric gases, bacteria, virus, particulate substances, turbidity by soil and natural debris, etc., and the next by
Human activities - handling of water like pollution by industrial and domestic wastes.

During the operation/journey from the water supply system to the consumer, water losses, pressure or flow reduction, and water quality deterioration may be caused by increasing concentrations of various organic, inorganic, or organometallic compounds and contaminants with various microorganisms says Matjaz Glavan, (2018).

Water conservation:

Sturman *et al*., (2004) defines water conservation in Global perspective as limiting or modifying the use of water by human beings, so that our use of water does not cause fluctuations of water quantity and quality within any cycle beyond those fluctuations caused by natural events within the time-scale of human history.

In a local setting it often means reducing the volume of water used for a single purpose or for complex systems of purposes. At the same time it implies

improving the quality of discharge water and, if possible, reducing the quantity of water required for the inputs to the purposes.

Water quality and ***water conservation*** are directly related with each other in determining water management in residential houses.

Methodology

The study consisted of the following stages.

Phase 1: Descriptive study: respondents' socio-demographic characteristics
Phase 2: Experimental investigation: Waters' Qualitative and Quantitative Status Quo
Phase 3: Knowledge Germination and Dissemination
Phase 4: Conceptualization of Design

The proposed ideation of the study is shown below in Fig:, 2, 3 and 4.

PHASE I: Descriptive study: respondents' socio-demographic characteristics

This part of the study was devised to gather information or the data on the following aspects:

→ ***Feasibility study (or the pilot study)***
→ ***Descriptive study (or Ex post facto research)***

The pilot survey was carried out in the sub areas located within the five zones of Coimbatore like Town Hall, Gandhipuram, Vellakinar, Thudiyalur, Kavundampalayam, Singanallur, Edayerpalayam, Kovilmedu and Podanur. For the pilot study samples were selected according to the convenience of the researcher. 20 samples from each zone were selected with the acceptance and the willingness expressed by the samples that they are involved in the pilot study.

Using ***survey method*** adopting ***personal interview*** the primary data was collected from the samples through ***an interview schedule*** on the basis of answers given by respondents. A multistage sampling technique was used to select the samples for the study.

Plate:1
Conducting Household survey

PHASE II: Experimental investigation: Waters' Qualitative and Quantitative Status Quo

The second phase of the study was designed to assess the water's quality from a variety of perspectives. The purpose of this section of the research was to collect information or data pertaining to the following aspects:

The quality of drinking water varies by location, depending on the state of the source water and the treatment it undergoes. The drinking water analysis for physical, chemical and biological properties including trace element contents are very important for public health studies.

This phase II of the current research was devoted to determining characteristics of drinking water quality and its methodology is addressed under the following headings:

1. **Examination of drinking water quality supplied in different zones of Coimbatore district**
2. **Inspection of potable water quality after common purification methods**
3. **Monitoring and assessing the quality of water stored in different containers**
4. **Water consumption analysis by micro components**

i. Examination of drinking water quality supplied in different zones of Coimbatore district

The physical, chemical and biological properties of the water collected from all the five zones of Coimbatore city were analyzed. Total five samples were taken from households, one sample from each zone in this experimental study period. The collected samples were taken to the certified laboratory for experimental study.

ii. Inspection of potable water quality after common purification methods

This part of the research endeavours to raise a heightened awareness regarding the quality of drinking water after it has been subjected to a number of treatments prior to being consumed by collecting the treated water samples from certain areas for the purpose of conducting an analysis. The data are analysed and compared with the WHO's guidelines for safe drinking water and Indian Standards of Drinking Water. Out of the five zones of the Coimbatore city, west zone was picked by the researcher.

Five drinking water samples that were chosen for the study is as follows:

1. Boiled water (Rolling boil for 1 minute)
2. Purified water (Using membrane filters)
3. RO water (Reverse Osmosis)
4. Packaged drinking water (Leading brand)
5. Directly fetched water from the distribution tap (Without treatment)

iii. Monitoring and assessing the quality of water stored in different containers

An attempt was made by the researcher to bring forth facts on qualitative data of the chosen water samples that had been held for a specified amount of time (i.e. the frequency of drinking water distribution) for its consumption. ***Convenience sampling*** was utilised to choose the water sample from a household, out of the targeted sample area (west zone). It also revealed that people use a variety of containers made of various materials such as aluminium, brass, copper, earthenware pots, plastic and stainless steel, to preserve drinking water for later use. The researcher made an effort to profoundly find the

(i) qualitative facet – ameliorate / deteriorate qualities and the

(ii) affiliation if any that persist between the frequency of water distribution and the water storage containers by allowing the gathered water samples through the physical, chemical, and biological tests.

The data are examined and compared to the WHO's recommendations for safe drinking water, and Indian Standards of Drinking Water.

iv. Water consumption analysis by micro components

Homemakers from Coimbatore west zone were chosen as the targeted samples for this sector of research using convenience sampling method. The most accurate way to evaluate the basic factor is to break down water use per capita into micro-components. If we don't know the micro-component values of water consumption, we won't be able to know how much water we use in the bathroom, kitchen, laundry, and so on.

PHASE III: Knowledge Germination and Dissemination

The third phase of the project was focused to the implementation and evaluation of an intervention programme on the socio-demographic pattern, knowledge, attitude, degree of awareness, and current practises of the households in connection to residential water management. In order to address the challenges, it was determined that homemakers should be educated on many elements of water management, including demand and supply situations, water conservation methods and techniques, as well as the necessity, significance, and benefits of successful household water management. Under the following categories, Phase III of the present research is described.

1. Selection of target region and samples
2. Development of learning modules for knowledge dissemination on residential water management
3. Conducting the residential water management knowledge dissemination program
4. Effectiveness of the residential water management knowledge dissemination program

Ward No. 35 and 42 in the West zone was selected for the knowledge dissemination programme because the proportion of persons who indicated a desire to attend the event is relatively high in comparison to other zones. In the midst of an increase in COVID 19 cases throughout the nation, the awareness session was carried out through a virtual mode. Out of the contacted 182 homemakers, 101 have showed great willingness to participate in the program. Only 65 homemakers were able to engage in the online knowledge dissemination programme.

Learning modules – ***written materials, electronic material and interpersonal means of communication*** were developed specifically for homemakers with the goals of enhancing in understanding the concepts of water, informing them the impact of lackadaisical water use practises, and extending their knowledge of the appropriate methods of water storage to sustain its quality, as well as various water conservation measures at the household level.

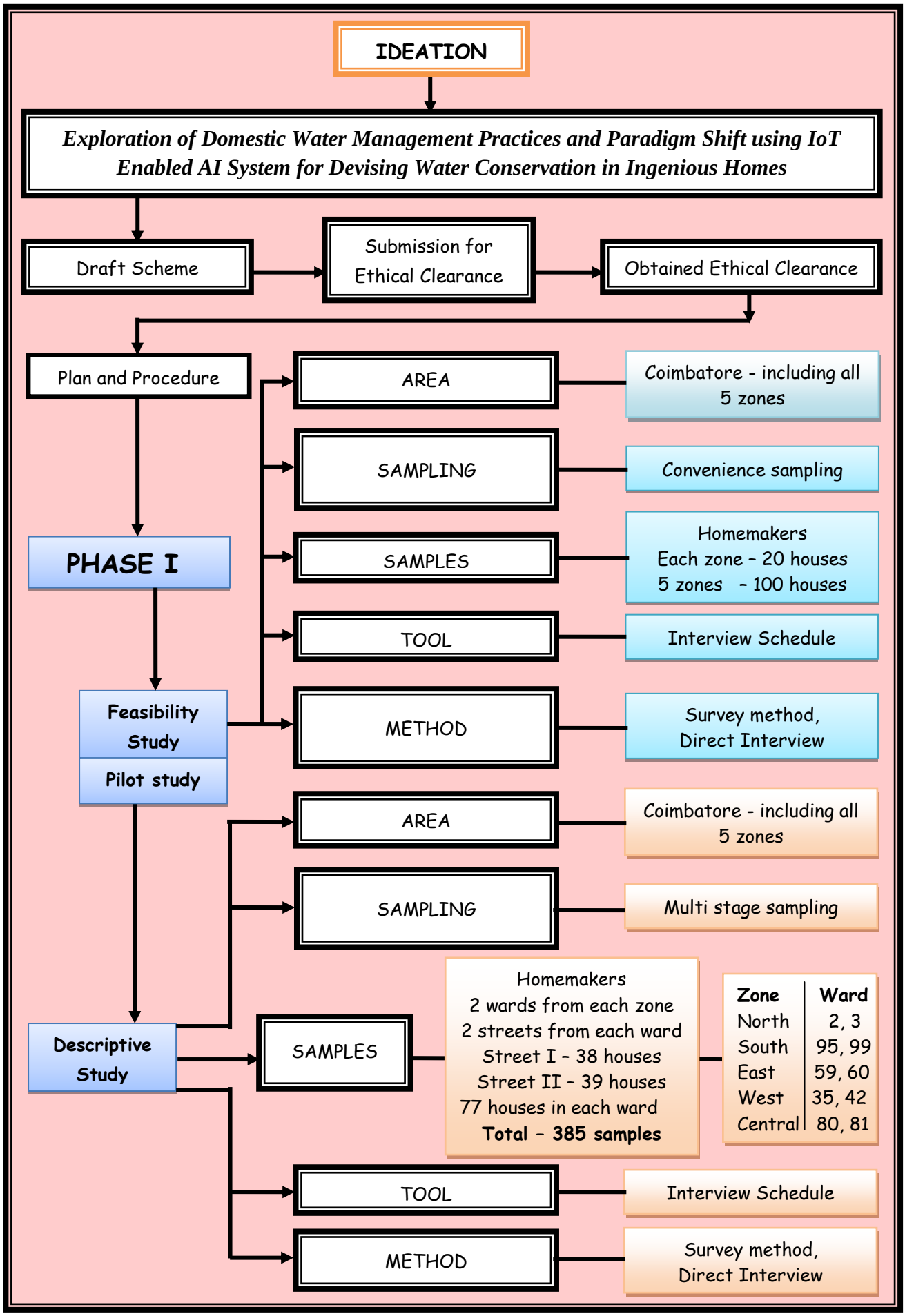


Figure: 1
Phase I - Descriptive study: respondents' socio-demographic characteristics

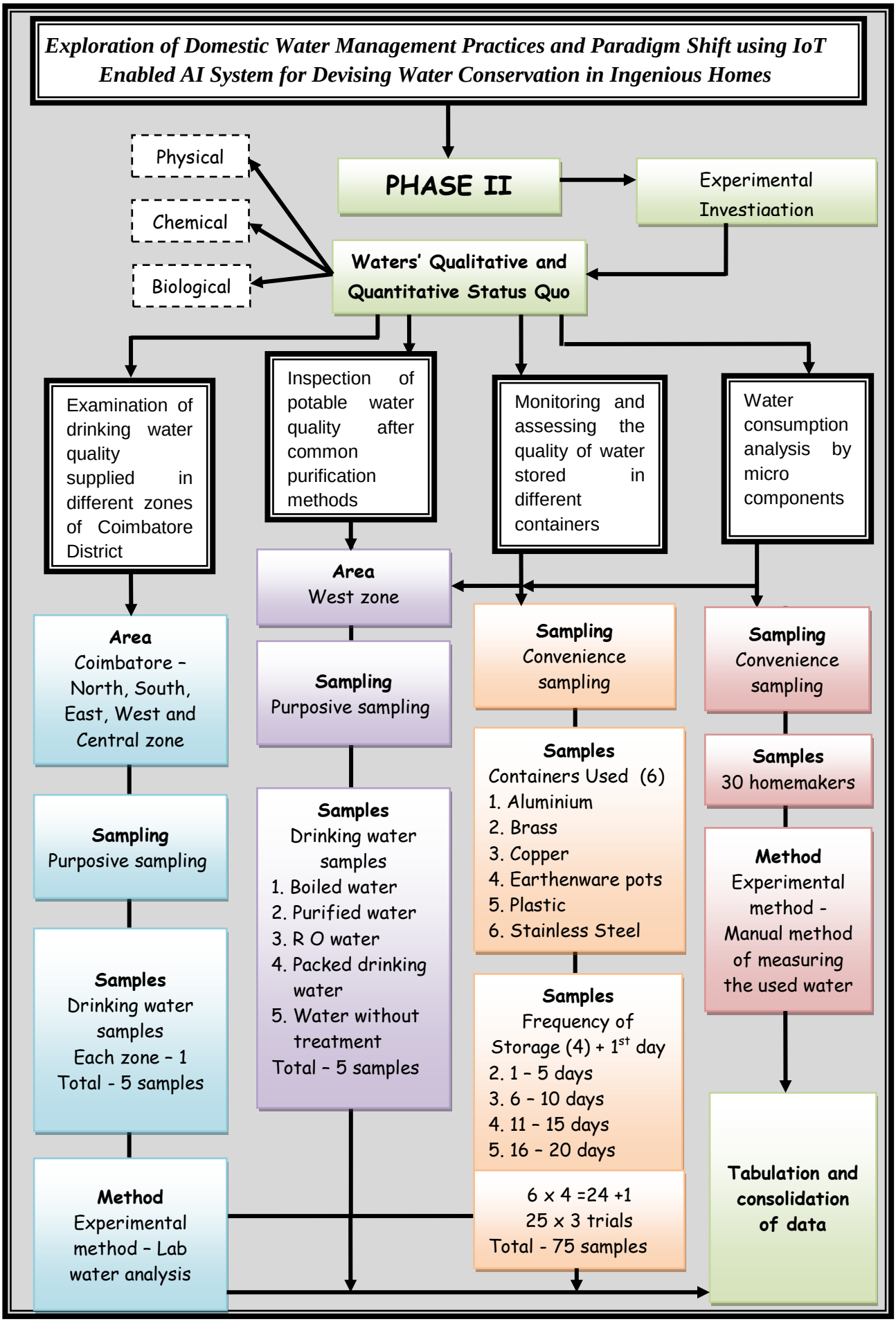


Figure: 2

Phase II - Experimental investigation: Waters' Qualitative and Quantitative Status Quo

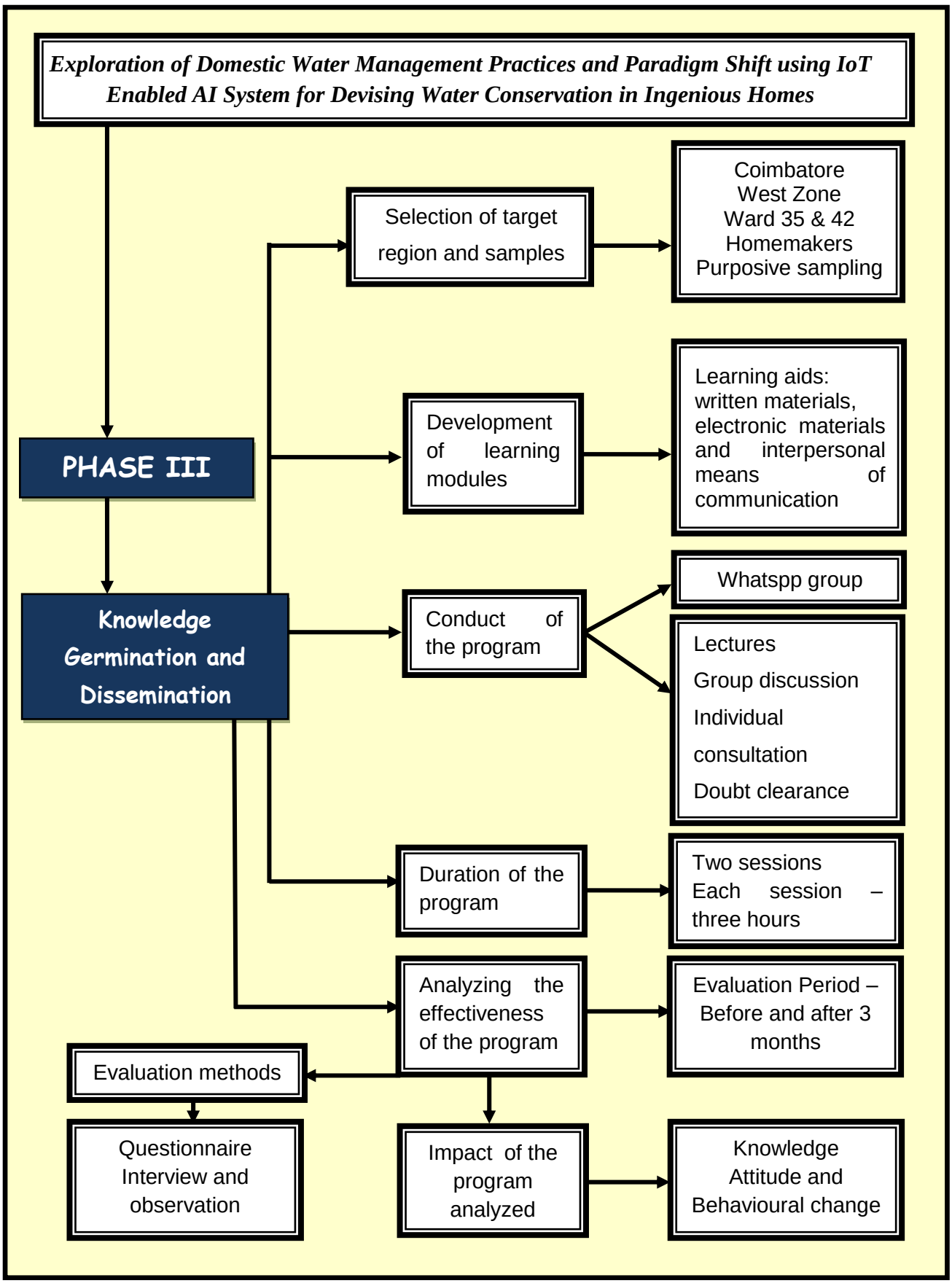

Exploration of Domestic Water Management Practices and Paradigm Shift using IoT Enabled AI System for Devising Water Conservation in Ingenious Homes
PHASE III
Knowledge Germination and Dissemination
Selection of target region and samples
Coimbatore West Zone Ward 35 & 42 Homemakers Purposive sampling
Development of learning modules
Learning aids: written materials, electronic materials and interpersonal means of communication
Conduct of the program
Whatspp group
Lectures
Group discussion
Individual consultation
Doubt clearance
Duration of the program
Two sessions Each session – three hours
Analyzing the effectiveness of the program
Evaluation Period – Before and after 3 months
Evaluation methods
Questionnaire Interview and observation
Impact of the program analyzed
Knowledge Attitude and Behavioural change

Figure: 3
Phase III – Knowledge Germination and Dissemination

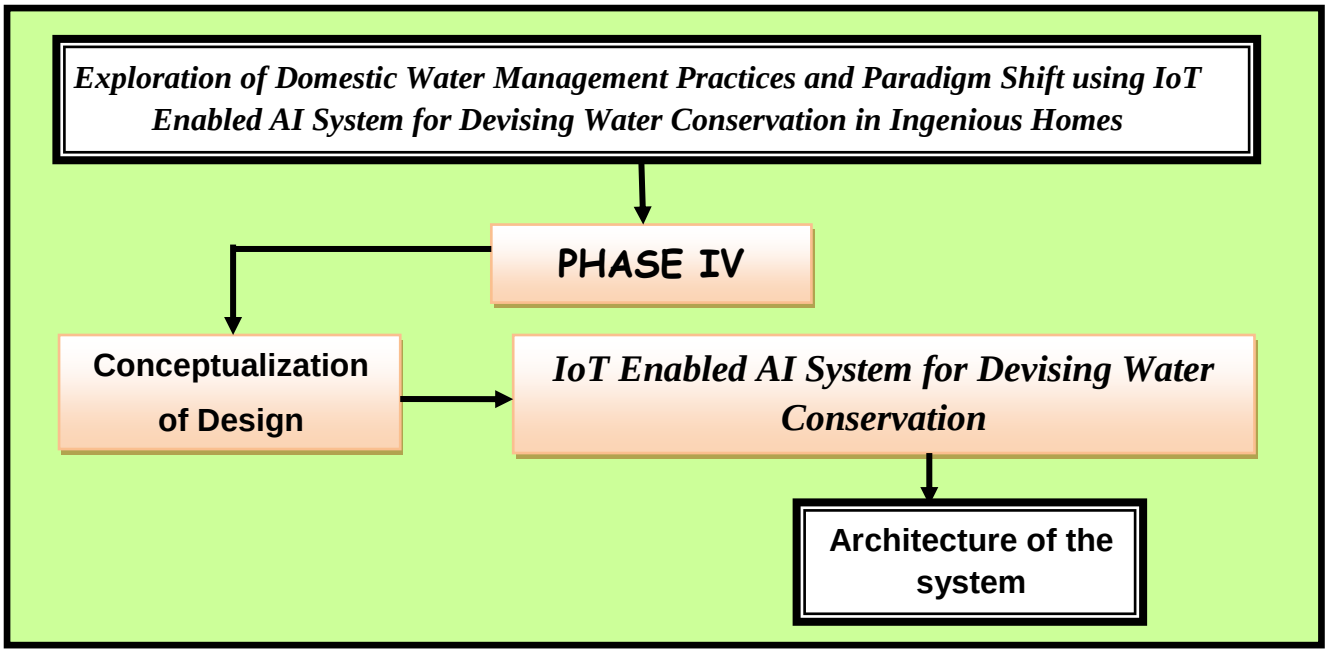

Exploration of Domestic Water Management Practices and Paradigm Shift using IoT Enabled AI System for Devising Water Conservation in Ingenious Homes
PHASE IV
Conceptualization of Design
IoT Enabled AI System for Devising Water Conservation
Architecture of the system

Figure: 4
Phase IV – Conceptualization of Design

PHASE IV: Conceptualization of Design

In this Phase IV, an effort was made to design and create: ***IoT Enabled AI System for Devising Water Conservation.*** The design of this water system adhered to the ideas and procedures outlined in the researcher's review of this specific subject. The design of the ***IoT Enabled AI System for Devising Water Conservation*** was developed. The conceptualization design of the invention is discussed elaborately under the following headings.

- Conspectus of the invention
- Existing state of art and highlights of the invention
- Novelty and utility of the invention
- Highlights of the invention
- Objectives of the invention
- Detailed description of the invention
- Block diagram representing architecture of the invention
- Honor and integrity of the invention

Results and discussion

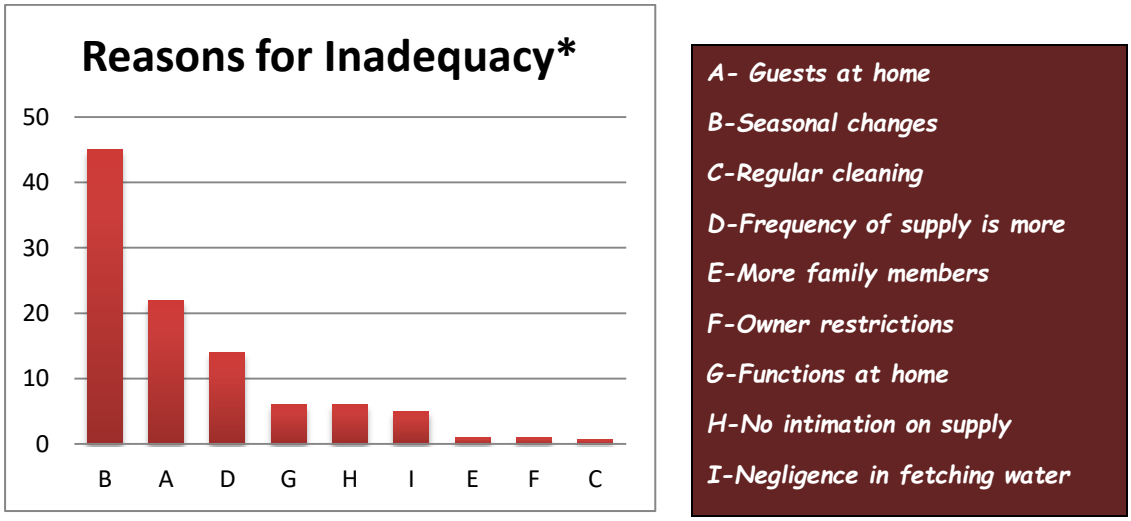
From **Phase I** The overall result of socio-economic profile of the homemakers shows that more number of homemakers were in the age group of 41 – 50 years completed middle high schooling and graduation and were full-time homemakers. Most of them live in a nuclear system of family having four members in their family. Majority earn around Rs.20,000 – 30,000 per month. A greater number of the households live in their own independent houses for more than 10 years. The results of this part of study discuss the relationship between knowledge of water conservation, usage of water conservation tools and presence of rainwater harvesting

with the qualification of the homemaker, Income of the family, ownership status and type of house.

Chi-square analysis was executed to find the association between socio-demographic variables of the homemaker and the installation of rainwater harvesting system. The critical value (X^2 = 15.758; p=0.027) leads to the possibility of a significant association between variables significant at 5% level. 40.5 per cent of the respondents have revealed that their water is wasted maximum in the toilets while flushing, and dishwashing (kitchen utensil cleaning) take up the next water wastage area with 39.7 per cent and 27.3 per cent when filling the overhead tank. These three areas are identified to be the red spots related to water wastage.

One-way ANOVA was carried out to analyse the difference in the behaviour of water wastage among the respondents based on their educational qualifications. The difference in the frequency of water supply has been recorded in two periods (ie) i). Seasonal – the period during summer in April, May and June ii). Non-seasonal – months other than summer like January, February, and March. The homemaker's opinion towards the quality and quantity of the water was found using an attitude scale from highly satisfied, satisfied, partially satisfied, and finally not satisfied.

A proportion (12.2%) of respondents were highly satisfied and satisfied (34%) with the quality of water. A total of 14.8 percent were highly satisfied and 55.6 per cent were satisfied with the quantity of water delivered to them during months whenever supply exceeds demand (non-seasonal period).



* Multiple responses

Figure: 5
Reasons for Inadequacy

At 1% significance level, a highly significant association was identified between the attribute of satisfaction on the distributed soft water quality during the summer of the selected respondents and zonal division in Coimbatore, as indicated by the obtained critical value (X2 = 26.201; p = 0.010).

An attempt was made in **Phase II** to examine the quality of the collected water from the five zones of the city with the Indian Standard Drinking Water Specifications and WHO drinking water specifications. It is inferred that all the characteristics and components of water are seen to be within the acceptable and permissible limit when the water has been collected from the distribution tap during the water supply.

It was noticed that all the selected water samples were free from micro biological contamination (E.Coli, Coliforms). Total plate count seems to be higher (<20 CFU/ml) i.e 65 CFU/mg in west zone and 130 CFU/mg in south zone water samples) indicates that in west and south zones there exist threat on water quality with special reference to biological contamination.

The physical, chemical and the biological parameters of the drinking water after undergone a range of water treatments and without any treatment as well was analyzed. The desirable pH range of drinking water is 6.5-8.5. Among the physical parameters turbidity ranges between 2.24 – 0.59 NTU. In the part of the study potable water quality after common purification methods EC value ranges between 0.04 µS/cm – 0.27 µS/cms. Leading packaged drinking water has high TDS value (420 mg/l), while low TDS was shown in RO water (168 mg/l). In the water samples, hardness ranges between 20.09 – 68.84 mg/l. Highest value of hardness was observed in packaged drinking water while water that has not undergone any of the water purification method had low hardness.

As drinking water was not supplied on daily basis, people commonly store the supplied water from a minimum of 5 days to a maximum up to 20 days. During summer the frequency may extend up to 25 days also. The research attempted to investigate the effect of different types of storage vessels such as aluminium, brass, copper, mud, plastic, and steel on water quality which was commonly used for water storage among the selected households from the West zone of the selected city. The physical, chemical and biological parameters of the water collected during water supply and after storing the water in different vessels for a maximum of 20 days were also analyzed.

The use of conventional storage vessels like copper and clay pots are declining. People tend to depend on modern techniques and procedures for water purification instead of easy and affordable conventional. Therefore this analysis was intended to determine the effect of different storage vessels on the purity of water and there by protect and promote the human health.

The test is used to examine on a routine basis samples (100 ml in a single culture container) collected in every 5 days. The collected water was stored under home conditions and the biological parameters were tested in a frequency of five days for a total storage of 20 days. The same mode was followed with the analysis during the multiple storage days. Overall three trials were made with the analysis of storage water to determine the occurrence of the micro organisms.

Results obtained in this study reveals that quality of water stored in brass and copper is the best compared to the other containers like aluminium, mud and stainless

steel. It is also safe and sound to consume the distributed water that was stored up to 10 days, and hale and healthy to use copper and brass containers for drinking water storage.

The results of descriptive analysis show that of the total water usage, 66.69% (483.57 ± 236.83L) was used for activities like washing of clothes, bathing, and flushing of the toilet. About 19.33% (151.98±98.27L) of the water was used for cooking and washing utensils. A mere 2.90% (19.82±8.96L) of the water was used for other basic activities like drinking and brushing. The rest of the water (10.94%) was spent for external household activities like gardening, vehicle washing, and other purposes.

The findings show that the highest quantity of water was consumed in bathrooms and toilets. Similarly, toilets consume a high quantity of water. Leakages in flush tanks often contribute to the wastage of a large quantity of water. The study shows that a considerable quantity of water was used for cleansing the clothes manually. Based on these results, it can be inferred that manual flushing consumed lesser quantity of water per head when compared to single flush and dual flush and fully automatic washing machines consumed lesser quantity of water when compared to manual and semi-automatic machines.

The findings of the t-test demonstrate that there is no significant difference between the homemakers and paid servants with the amount of water consumed for washing clothes and utensils ($P>0.05$); thereby, suggesting that water consumption for household chores did not vary between homemakers and paid assistants.

In **Phase III** further analysis was made to assess the level of awareness on water conservation and behavioural attitude towards water management among the selected households. It can be seen that among the total number of 65 households, 1.5 per cent of the respondents strongly agree that water was being wasted before the knowledge dissemination programme. Similarly 18.5% of people admitted that water was being wasted, however after their participation in the programme, just 1.5% of people believed that they are wasting water.

Conclusion

As a result of the existing problem, which leads to this research study a water conservation mechanical assemble was developed with the primary goal to keep track of how much water each water outlet uses every day, alert the user by tracking the comparative data (days/months) of water expenditure through SMS/alarm/display in LCD, Identify the water leakage in any water outlet, thereby reducing the unnecessary flow of water in houses. Knowledge dissemination programme was taken place for effective usage of our SCARCE RESOURCE – THE WATER

Scope of Future Work

- The conversion of the prototype into a product can be taken into account for further studies.

- Research can be taken to the next level by analyzing water usage in commercial sector activities
- Focus on the reduction in the cost of product fabrication.

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